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Review

What proportion of people with hip and knee osteoarthritis meet physical activity guidelines? A systematic review and meta-analysis

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SUMMARY

Objective: To determine the proportion of people with hip and knee osteoarthritis that meet physical activity guidelines recommended for adults and older adults.
Method: Systematic review with meta-analysis of studies measuring physical activity of participants with hip and knee osteoarthritis using an activity monitor. Physical activity levels were calculated using the mean average [95% confidence interval (CI)] weighted according to sample size. Meta-analyses determined the proportion of people meeting physical activity guidelines and recommendations of (1) ≥150 min per week of moderate to vigorous physical activity (MVPA) in bouts of ≥10 min; (2) ≥150 min per week of MVPA in absence of bouts; (3) ≥10,000 steps per day and ≥7000 steps per day. The Grades of Research, Assessment, Development and Evaluation (GRADE) approach was used to determine the quality of the evidence.
Results: For knee osteoarthritis, 21 studies involving 3266 participants averaged 50 min per week (95% CI = 46, 55) of MVPA when measured in bouts of ≥10 min, 131 min per week (95% CI = 125, 137) of MVPA, and 7753 daily steps (95% CI = 7582, 7924). Proportion meta-analyses provided high quality evidence that 13% (95% CI = 7, 20) completed ≥150 min per week of MVPA in bouts of ≥10 min, low quality evidence that 41% (95% CI = 23, 61) completed ≥150 min per week of MVPA in absence of bouts, moderate quality evidence that 19% (95% CI = 8, 33) completed ≥10,000 steps per day, and low quality evidence that 48% (95% CI = 31, 65) completed ≥7000 steps per day.
For hip osteoarthritis, 11 studies involving 325 participants averaged 160 min per week (95% CI = 114, 216) of MVPA when measured in bouts of ≥10 min, 189 min per week (95% CI = 166, 212) of MVPA, and 8174 daily steps (95% CI = 7670, 8678). Proportion meta-analyses provided low quality evidence that 58% (95% CI = 18, 92) completed ≥150 min per week of MVPA in absence of bouts, low quality evidence that 30% (95% CI = 13, 50) completed ≥10,000 steps per day, and low quality evidence that 60% (95% CI = 47, 73) completed ≥7000 steps per day.
Conclusion: A small to moderate proportion of people with knee and hip osteoarthritis met physical activity guidelines and recommended daily steps. Future research should establish the effects of increasing physical activity in this population to meet the current physical activity guidelines.

Introduction

Pain associated with mobility is characteristic of people with hip and knee osteoarthritis. Because of impaired mobility associated with weight bearing pain, people with osteoarthritis may not be expected to be as physically active as people without osteoarthritis[1–4]. Reductions in physical activity may be further accentuated if people with osteoarthritis believe physical activity is not beneficial or harmful for their joint[5]. Sufficient physical activity is important for people with knee or hip osteoarthritis as the risk of mortality from cardiovascular causes is increased in this population with walking disability[6].

Physical activity is defined as any bodily movement produced by skeletal muscle that requires energy expenditure[7] ranging from occupational, recreational or household tasks as well as structured activities like exercise classes, and categorised into light, moderate

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and vigorous intensity. Current physical activity guidelines for adults and older adults recommend at least 150 min per week of moderate to vigorous physical activity (MVPA) in bouts of 10 min or more[8–10]. Steps per day are a frequently used metric for assessment of physical activity, specifically walking, and a popular recommendation is 10,000 daily steps[11]. Furthermore 7000 daily steps may be equivalent to 150 min per week of physical activity in absence of the bout criterion[12].

Activity monitors provide meaningful information to compare with physical activity guidelines and recommended daily steps[13]. Only one previous review was found that investigated the physical activity levels of people undergoing total joint arthroplasty using activity monitors[14]. The results of the Naal and Impellizzeri[14] review concluded that people undergoing joint arthroplasty walked an average of 6721 steps per day which is less than the popular recommendation of 10,000 steps per day and 7000 steps per day. The Naal and Impellizzeri review, however, did not examine the proportion of people with osteoarthritis meeting physical activity guidelines and only included a relatively small number of studies ($n = 6$) which measured physical activity pre-operatively with accelerometers.

Therefore, the current review had two main aims: (1) to determine the physical activity levels of people with hip and knee osteoarthritis measured by an activity monitoring device; (2) to determine the proportion of people with hip and knee osteoarthritis that met current physical activity guidelines and recommendations for adults and older adults.

Method

Design

PROSPERO registration number CRD42012002416 http://www.crd.york.ac.uk/PROSPERO. Systematic review of empirical studies of multiple designs including observational, cross-sectional and interventional (using baseline data).

Search strategy

The electronic databases MEDLINE, PUBMED, CINAHL, EMBASE, COCHRANE and SPORTdiscus were searched from earliest available time until April 2012. The two concepts population and outcome were combined with the 'AND' operator. Population was defined as participants with osteoarthritis of the hip and knee. Outcome was defined as a physical activity measure using an activity monitor (accelerometer or pedometer) for a minimum of 1 day. For each concept synonyms and MeSH terms were combined with the 'OR' operator (Appendix).

All articles were imported to bibliographic software. Two reviewers independently screened each article for inclusion by title and abstract utilising pre-determined eligibility criteria. Any disagreements were resolved by discussion. Full text copies of articles that were not definitely excluded on title and abstract were retrieved and the criteria reapplied. If uncertain, articles were discussed by the reviewers to achieve consensus. Database searching was supplemented by hand searching the reference lists of included articles and the application of citation tracking using Google Scholar.

Eligibility criteria

The studies were eligible if (1) participants were diagnosed with hip or knee osteoarthritis. If the study included other conditions such as rheumatoid arthritis but did not separate the outcomes then the study was eligible if at least 80% of participants had hip or knee osteoarthritis; (2) a direct measure of physical activity (accelerometer or pedometer) was used for a minimum of 1 day; (3) the study was peer reviewed; (4) written in English.

The studies were ineligible if (1) they were animal studies; (2) they evaluated the effect of an intervention (such as joint arthroplasty) without baseline data; (3) the physical activity measure was not an activity monitoring device such as a questionnaire or diary; (4) the article was not peer reviewed such as an opinion article or thesis; (5) the article was a systematic review.

Data collection process

A pre-designed form was used to extract data on participants, type of activity monitor and results including strategies (if any) associated with physical activity and health outcomes. Investigators were contacted, if required, to confirm data.

Risk of bias in individual studies

Two researchers independently applied a validated tool, the Epidemiological Appraisal Instrument, to rate the methodological quality of all the trials[15] and 23 items (item numbers 1, 3–9, 11, 13–17, 19, 21, 31, 32, 35, 36, 41–43) were applicable to this review. Each item was scored with 'yes' (scored as 2), 'partial' (scored as 1), and 'no' or 'unable to be determined' (scored as 0) with a maximum score of 46 (100%). A trial with a score of 60% or more was considered high quality[1].

Synthesis of results and summary measures

To describe the physical activity level of participants, the mean average physical activity level [95% confidence interval (CI)] was calculated and weighted according to sample size as represented by: (1) the number of minutes per week of MVPA in bouts of 10 or more minutes; (2) the number of minutes per week of MVPA in the absence of bouts; (3) the number of daily steps.

The principal summary measures were as follows: (1) the proportion of participants (95% CI) that met current physical activity guidelines of at least 150 min per week of MVPA in bouts of 10 or more minutes; (2) the proportion of participants (95% CI) that completed at least 150 min per week of MVPA in absence of the bout criterion; (3) the proportion of participants (95% CI) that completed the popular recommendation of 10,000 steps per day and the proportion that completed 7000 steps per day, estimated to be equivalent to completing 150 min per week of MVPA in absence of the bout criterion.

Where the proportion of participants meeting the physical activity guidelines or recommended number of daily steps were not reported a secondary analysis estimated the results based on *z*-scores (mean, standard deviation, number of participants). The data were combined *via* proportion meta-analyses (StatsDirect, Altrincham, UK) using a random effects model[16] where at least two trials had a common population (e.g., knee osteoarthritis) and outcome measure (e.g., number of daily steps). The CIs were calculated by the "exact" method[17]. Sensitivity analyses were performed when high statistical heterogeneity ($I^2 > 50\%$)[18] was present by eliminating outlier results. Subgroup analyses were performed to investigate factors related to physical activity level.

Risk of bias across studies

The Grades of Research, Assessment, Development and Evaluation (GRADE) approach was applied to each meta-analysis

performed to determine the quality of the evidence[19]. This approach involved grading the evidence based on criteria for (1) inconsistency of results (downgrade if $I^2 \geq 50\%$ indicating high heterogeneity; and there was no plausible explanation to explain the inconsistency of results); (2) indirectness of results (no downgrade applied as all studies measured physical activity with an activity monitor, which is the best available method of objectively and feasibly estimating physical activity); (3) imprecision of results (downgrade applied if large CI, defined as a total interval >25% representing a quartile) and (4) risk of bias across studies (downgrade if Epidemiological Appraisal Instrument score average <60%).

Results

Study selection

The electronic database search yielded 2020 papers. By applying eligibility criteria to title and abstract [inter-rater agreement $\kappa = 0.57$ (95% CI = 0.47, 0.67)] 83 papers were retrieved for full text review. By reapplying the eligibility criteria to the full text [inter-rater agreement $\kappa = 0.95$ (95% CI = 0.88, 1.0)] 30 papers fulfilled inclusion criteria. Five further papers were located *via* citation tracking. Of the 35 papers, eight had reported the same participant data of interest therefore the final yield was 27 studies with original participant data for hip and knee osteoarthritis (Fig. 1).

Risk of bias in individual studies

The majority of the studies were rated as high quality [inter-rater agreement $\kappa = 0.37$ (95% CI = 0.30, 0.44)] with an average score of 83% (Tables I–III). There was an initial difference in interpretation of criteria mainly relating to two items regarding measurement quality that was resolved at a consensus meeting. The items most commonly unfulfilled related to data analysis of subgroups of participants and reporting sample size calculations.

Study characteristics

Participants

There were 3266 participants with knee osteoarthritis from 21 studies, weighted mean age of 64 years, body mass index of 30, 63% were women and 63% had severe osteoarthritis (grade III or IV)[20] (Tables I and III).

There were 325 participants with hip osteoarthritis from 11 studies, weighted mean age of 55 years, body mass index of 26, 68% were women and 90% had severe osteoarthritis (grade III or IV)[20] (Tables II and III).

For selection of participants with knee or hip osteoarthritis, eight studies referred to Kellgren–Lawrence[20] criteria, four studies referred to American College of Rheumatology criteria[21,22], one study referred to each of the following: Osteoarthritis Research Society International criteria[23], Danielsson criteria[24] and Yokohama

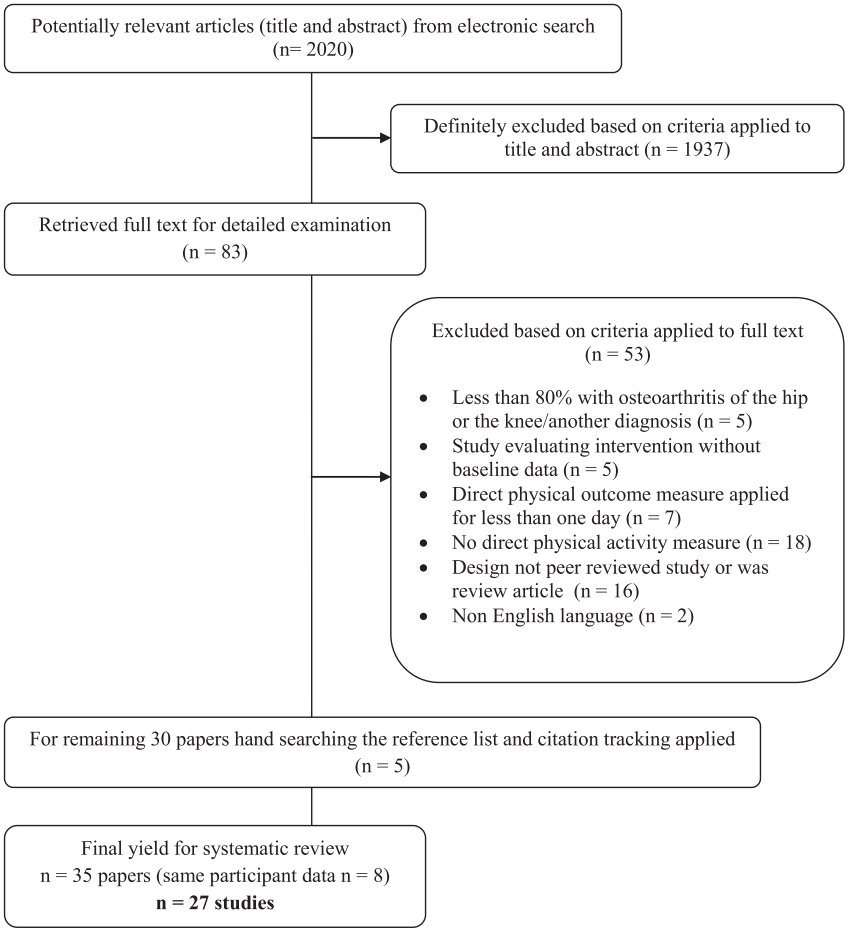

Fig. 1. Trial selection process.

Table I
Study characteristics and physical activity results for knee osteoarthritis

Study Country	Knee OA participants	Activity monitor Number of days monitored	Physical activity level	Proportion meeting guidelines (95% CI)	Study quality (EAI)
Hurley *et al.*[42] Canada	*n* = 24 (Community) Age = 57.8 (8.1) Female % = 17 BMI = 31.8 (5.2) OA severity % = 58	Pedometer 21 days	Steps/day = 5740 (3313)	≥10,000 steps/day = **10% (2, 29)** ≥7000 steps/day = **35% (17, 57)**	67%
Michishita *et al.*[43] Japan	*n* = 37 (Outpatient) Age = 60.1 (6.7) Female % = 100 BMI = 28.2 (3.7) OA severity % = 11	Life-corder 7 days	Steps/day = 5455 (2625) Energy expenditure = 25.2 (3.3) kcal/(kg day)	≥10,000 steps/day = **4% (0, 16)** ≥7000 steps/day = **28% (14, 45)**	72%
Robbins *et al.*[44] Canada	*n* = 38 (Outpatient) Age = 54.0 (7.0) Female % = 26 BMI = 30.4 (4.2) OA severity % = 53	GT1M, ActiGraph 7 days	Steps/day = 7136 (2748)	≥10,000 steps/day = **15% (5, 30)** ≥7000 steps/day = **52% (35, 68)**	91%
Talbot *et al.*[45] Talbot *et al.*[46] USA	*n* = 34 (Community) Age = 70.5 (5.3) Female % = 79 BMI = 30.5 (5.0) OA severity % = 38	Tritrac R3D and Pedometer - digi -walker 3 days	Steps/day = 4600 (2949)	≥10,000 steps/day = **3% (0, 16)** ≥7000 steps/day = **21% (9, 38)**	87% 85%
Tonelli *et al.*[2] USA	*n* = 208 (Surgical waiting list) Age = 61.8 (10.0) Female % = 100 BMI = 34.7 (7.3) OA severity % = 100	ActivPal 7 days	Steps/day = 4726 (2787) Average METS/day = 32.4 (1.2)	≥10,000 steps/day = **3% (1, 6)** ≥7000 steps/day = **21% (15, 27)**	74%
Watanabe *et al.*[30] Japan	*n* = 18 Age = 67.0 (8.0) Female % = 100 BMI = 23.0 (3.0) OA severity % = 0	Life-corder 9 days	Steps/day = 8016 (3283) Energy expenditure (kcal/day) = 179 (89)	≥10,000 steps/day = **27% (9, 53)** ≥7000 steps/day = **62% (37, 83)**	65%
White *et al.*[47] USA	*n* = 1018 (Multicentre Osteoarthritis study) Age = 63.1 (7.8) Female % = 60 BMI = 31.7 (6.3)	Step Watch 7 days	Steps/day = 8395 (3469)	≥10,000 steps/day = **32% (29, 35)** ≥7000 steps/day = **66% (63, 68)**	89%
Brandes *et al.*[48] Germany	*n* = 53 (Surgical waiting list) Age = 65.8 (5.8) Female % = 64 BMI = 30.7 (4.1) OA severity % = 100	Step activity monitor 3.0 7 days	Steps/day = 9986 (4340) Min/week MPA @ 81–100 steps/min = 191 (137) Min/week MVPA @ > 100 steps/min = 82 (115) Min/week MVPA @ > 80 steps/min = 273 (125)	≥10,000 steps/day = **50% (36, 64)** ≥7000 steps/day = **75% (62, 86)** ≥150 min/week MVPA @ > 80 steps/min = **84% (71, 92)**	78%
Winter *et al.*[31] Germany	*n* = 30 (Surgical waiting list) Age = 63.2 (3.8) Female % = 50 BMI = 29.8 (5.9) OA severity % = 100	Step Watch 5–10 days	Steps/day = 9350 (3815) Min/week MVPA @ > 100 steps/min = 17.5 (23.1)	≥10,000 steps/day = **43% (25, 63)** ≥7000 steps/day = **73% (54, 88)** ≥150 min/week MVPA @ > 100 steps/min = **0% (0, 12)**	91%
Lee *et al.*[3] Dunlop *et al.*[41] Song *et al.*[50] USA	Lee (*n* = 1089) Dunlop (*n* = 1111) Song (*n* = 519) (Osteoarthritis Initiative) Age = 66.1 Female % = 55 OA severity % = 67	GT1M Actigraph 7 days	Min/week inactivity @ < 100 counts/min = 596 (94)[41] Min/week LPA @ 100–2019 counts/min = 276 (78)[41] Min/week MVPA @ > 2019 counts/min = 98 (112)[50] Min/week MVPA @ > 2019 counts/min in BOUTS ≥ 10 min =50 (89)[41] Activity counts/day = 190,225 (97,876)[50]	≥150 min/week MVPA @ > 2019 counts/min in BOUTS≥10 min = **10% (8, 12)** ≥150 min/week MVPA @ > 2019 counts/min = **32% (28, 36)**	93% 96% 85%

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Table I (*continued*)

Study Country	Knee OA participants	Activity monitor Number of days monitored	Physical activity level	Proportion meeting guidelines (95% CI)	Study quality (EAI)
Farr *et al.*[40] Farr *et al.*[51] USA	n = 255 (Community) Age = 54.6 (7.1) Female % = 77 BMI = 27.8 (4.3) OA severity % = 0	MT1 Actigraph 7 days	Min/week MPA @ 3–6 METS = 165 (120) Min/week VPA @ > 6 METS = 6.7 (24.5) Min/week MVPA @ ≥ 3 METS = 172 (134)	≥150 min/week MVPA @ ≥ 3 METS = **56% (50, 63)**	85% 93%
Semanik *et al.*[52] Manheim *et al.*[4] USA	Semanik (n = 139) Manheim (n = 142) (community, outpatient) Age = 63.0 (13.0) Female % = 58 BMI = 31.0 (6.0) OA severity % = 47	GT1M, ActiGraph 7 days	Min/week LPA @ 100–2019 counts/min = 3276 (700) Min/week MVPA @ > 2020 counts/min = 140 (140) Min/week MVPA @ > 2020 counts/min in BOUTS ≥ 10 min =56 (98) Activity counts/day = 220,915 (110,149)	≥150 min/week MVPA @ > 2019 counts/min in BOUTS ≥ 10 min = **17% (11, 24)** ≥150 min/week MVPA @ > 2019 counts/min = **47% (39, 56)**	85% 91%
Fary *et al.*[53] Australia	n = 70 (Community) Age = 69.8 (10.3) Female % = 47 BMI = 28.1 (5.1) OA severity % = 75	Activity monitor (not specified) 6 days	Min/week inactivity = 6874 (649) Min/week LPA = 2373 (550) Min/week MPA = 791 (4223) Min/week VPA = 0.98 (3.5) Activity counts/day = 194,243 (90,513)	Unable to report Activity intensity was not defined clearly in the study to be able to estimate proportion meeting guidelines.	87%
de Groot *et al.*[26] de Groot *et al.*[27] Vissers *et al.*[35] Netherlands	n = 44 (Surgical waiting list) Age = 62.1 (9.9) Female % = 55 BMI = 32.1 (5.3) OA severity % = 95	Rotterdam activity monitor 2 days	Min/day of walking = 85 (38.9)	Unable to report Not able to convert data into MVPA or daily steps; less than 3 days of monitoring.	91% 83% 96%
Walker *et al.*[54] USA	n = 57 (n = 29 outpatient) (n = 28 surgical waiting list) OA severity % = 100	Numact, 1 day	Steps/day × average amplitude of steps 390,000 (75,000) 220,000 (55,000)	Unable to report Not able to convert data into MVPA or daily steps; less than 3 days of monitoring.	57%
Walker *et al.*[49] UK	n = 19 (Surgical waiting list) Age = 69.0 (6.1) Female % = 53 OA severity % = 100	Numact, 1 day	Steps/day = 10,738 Steps/day × average amplitude of steps =225,000 (50,000)	Unable to report Did not report the standard deviation for daily steps; less than 3 days of monitoring.	80%

n = number of participants; Age = mean years (standard deviation); BMI = mean kg/m^2 (standard deviation); MVPA = moderate to vigorous physical activity; LPA = light physical activity; MPA = moderate physical activity; VPA = vigorous physical activity; EAI = Epidemiological Appraisal Instrument; OA severity % refers to the percentage of participants with Kellgren–Lawrence[20] Score ≥3; participants on surgical waiting list were recorded as 100% if they did not report the Kellgren–Lawrence score; proportion meeting guidelines (primary outcome) bolded.

Table II
Study characteristics and physical activity results for hip osteoarthritis

Study Country	Hip OA participants	Activity monitor Number of days monitored	Physical activity level	Proportion meeting guidelines (95% CI)	Study quality (EAI)
Wollmerstedt *et al.*[55] Germany	$n = 26$ (Surgical waiting list) Age = 64 (7) Female % = 50 OA severity % = 100	Step Watch 5–7 days	Steps/day = 9934 (4308)	≥10,000 steps/day = **49% (29, 69)** ≥7000 steps/day = **75% (54, 90)**	70%
Winter *et al.*[31] Germany	$n = 30$ (Surgical waiting list) Age = 61.0 (14.8) Female % = 53 BMI = 26.0 (3.8) OA severity % = 100	Step Watch 5–10 days	Steps/day = 7988 (3911) Min/week of MVPA @ > 100 steps/min = 24 (83)	≥10,000 steps/day = **31% (15, 50)** ≥7000 steps/day = **60% (40, 77)** ≥150 min/week MVPA @ > 100 steps/min = **6% (1, 22)**	91%
Harris-Hayes *et al.*[56] USA	$n = 68$ (Surgical waiting list) Age = 40.9 (8.2) Female % = 53 BMI = 29.1 (6.0) OA severity % = 100	Step activity monitor 7 days	Steps/day = 8654 (4150) Min/week inactivity @ < 30 steps/min = 7342 (869) Min/week LPA @ 30–80 steps/min = 1555 (580) Min/week MPA @ 81–150 steps/min = 676 (348) Min/week VPA @ > 150 steps/min = 97 (106) Min/week MVPA @ > 80 steps/min = 773 (258)	≥10,000 steps/day = **37% (26, 50)** ≥7000 steps/day = **66% (53, 77)** ≥150 min/week MVPA @ > 80 steps/min = **99% (93, 100)**	91%
Hirata *et al.*[28] Japan	$n = 65$ (Outpatient) Age = 50 (10) Female % = 100 BMI = 21.4 (3.3) OA severity % = 66	Life-corder 7 days	Steps/day = 6646 (2420) Min/week LPA @ 1–3 METS = 372 (123) Min/week MPA @ 4–6 METS = 111 (81) Min/week VPA @ 7–9 METS = 8.4 (11) Min/week MVPA @ > 4 METS = 120 (81) Energy expenditure/day = 142 (66) kcal or 2.8 (1.2) kcal/kg	≥10,000 steps/day = **8% (3, 18)** ≥7000 steps/day = **44% (32, 57)** ≥150 min/week MVPA @ > 4 METS = **35% (24, 48)**	91%
Lin *et al.*[36] UK	$n = 12$ (Surgical waiting list) Age = 58.2 (3.7) Female % = 100 BMI = 23.4 (4.1) OA severity % = 100	RT3 7 days	Min/week MVPA @ METS = 168 (84) % of time/day of physical activity = 56 (14)	≥150 min/week MVPA @ METS = **58% (28, 85)**	74%
Svege *et al.*[39] Norway	$n = 40$ (Outpatient and community) Age = 61.3 (10.0) Female % = 50 BMI = 24.5 (3.6) OA severity = "less severe OA"	GT1M, ActiGraph 7 days	Min/week inactivity @ < 100 counts/min = 4018 (735) Min/week LPA @ 100–2019 counts/min = 1988 (672) Min/week MPA @ 2020–5999 counts/min = 294 (196) Min/week VPA @ > 6000 counts/min = 25 (50) Min/week MVPA @ > 2020 counts/min = 315 (224) Min/week MVPA @ > 2020 counts/min in BOUTS ≥ 10 min = 165 (160) Activity count/min = 370 (199)	≥150 min/week MVPA @ > 2019 counts/min in BOUTS ≥ 10 min = **54% (37, 69)** ≥150 min/week MVPA @ > 2019 counts/min **77% (61, 89)**	72%
de Groot *et al.*[26] de Groot *et al.*[27] Netherlands	$n = 40$ (Surgical waiting list) Age (yrs) = 61.4 (12.2) Female % = 60 BMI = 26.9 (4.2) OA severity % = 90	Rotterdam activity monitor 2 days	Min/day of walking = 92 (44.7)	Unable to report Not able to convert data into MVPA or daily steps	91% 83%

n = number of participants; Age = mean years (standard deviation); BMI = mean kg/m^2 (standard deviation); MVPA = moderate to vigorous physical activity; LPA = light physical activity; MPA = moderate physical activity; VPA = vigorous physical activity; EAI = Epidemiological Appraisal Instrument; OA severity % refers to the percentage of participants with Kellgren–Lawrence[20] Score ≥3; participants on surgical waiting list were recorded as 100% if they did not report the Kellgren–Lawrence score; proportion meeting guidelines (primary outcome) bolded.

City University Classification system[25]. The remaining nine studies selected participants from an elective surgical waiting list for joint replacement due to hip or knee osteoarthritis and one study selected participants with osteoarthritis diagnosed by a clinical specialist.

Physical activity measurement

The most common activity monitor was the GT1M Actigraph accelerometer in four studies whereby more than 2019 activity counts per minute was equivalent to MVPA. Another common device was the Step Watch used in three studies with more than 100 steps per minute equivalent to MVPA. The most common measure of physical activity reported was the number of daily steps taken in 15 studies and most common number of days monitored was 7 days (Tables I–III).

Synthesis of results

How active are the participants with knee osteoarthritis?

The weighted mean average was 50 min per week (95% CI = 46, 55) of MVPA when measured in bouts of at least 10 min from two studies of 1250 participants, 131 min per week (95% CI = 125, 137)

Table III
Study characteristics and physical activity results for hip and knee osteoarthritis

Study Country	Hip and knee OA participants	Activity monitor Number of days monitored	Physical activity level	Proportion meeting guidelines (95% CI)	Study quality (EAI)
Brandes *et al.*[32] Germany	n = 26 (Surgical waiting list) Knee OA (n = 7) Hip OA (n = 19) Age = 58.6 (13.4) Female % = 65 BMI = 27.6 (3.9) OA severity % = 100	Step activity monitor 3.0 7 days	Steps/day = 9564 (4232) Min/week inactivity @ 1–20 steps/min = 190 (58.6) Min/week LPA @ 21–80 steps/min = 135 (38.4) Min/week MVPA @ > 80 steps/min = 24.4 (15.3)	≥10,000 steps/day = **46% (27, 67)** ≥7000 steps/day = **73% (52, 88)** ≥150 min/week MVPA @>80 steps/min = **58% (37, 77)**	59%
Murphy *et al.*[58] Murphy *et al.*[59] Murphy and Smith.[62] USA	n = 40 (Research registry) Knee OA (n = 37) Hip OA (n = 3) Age = 63.1 (7.3) Female % = 100 BMI = 31.0 (5.6)	Actiwatch-S 5 days	Activity count/min = 317.8 (89.5) Peak activity count = 595.1 (137.2)	Unable to report Not able to convert data into MVPA	91% 91% 91%
Murphy *et al.*[61] USA	n = 54 (Community) Knee OA (n = 43) Hip OA (n = 11) Age = 75.3 (7.2) Female % = 89 BMI = 30.1 (5.7)	Actiwatch-S 3 days	Activity count/day = 204,517 (88,124) Peak activity count = 715.1 (298.3)	Unable to report Not able to convert data into MVPA	91%
Murphy *et al.*[57] Murphy *et al.*[60] USA	n = 32 (Community) Knee OA (n = 21) Hip OA (n = 11) Age = 61.8 (7.3) Female % = 75 BMI = 32.3 (6.7)	Actiwatch-S 5 days	Activity count/day = 331,533 (86,032) Peak activity count = 925.7 (224.9)	Unable to report Not able to convert data into MVPA	91% 91%

n = number of participants; Age = mean years (standard deviation); BMI = mean kg/m^2 (standard deviation); MVPA = moderate to vigorous physical activity; LPA = light physical activity; VPA = vigorous physical activity; EAI = Epidemiological Appraisal Instrument; OA severity % refers to the percentage of participants with Kellgren–Lawrence[20] Score ≥3; participants on surgical waiting list were recorded as 100% if they did not report the Kellgren–Lawrence score; Proportion meeting guidelines (primary outcome) bolded.

of MVPA from five studies of 1565 participants, and 7753 daily steps (95% CI = 7582, 7924) from 11 studies of 1486 participants.

How active are the participants with hip osteoarthritis?

The mean average was 160 min per week (95% CI = 114, 216) of MVPA when measured in bouts of at least 10 min from one study of 40 participants. The weighted mean average was 189 min per week (95% CI = 166, 212) of MVPA from four studies of 136 participants, and 8174 daily steps (95% CI = 7670, 8678) from five studies of 208 participants.

Proportion meta-analysis of participants with knee osteoarthritis meeting physical activity guidelines and recommendations

There was high quality evidence that 13% (95% CI = 7, 20) of 1228 participants from two studies met physical activity guidelines of at least 150 min per week of MVPA in bouts of minimum 10 min (Fig. 2, Table IV). There was low quality evidence that 41% (95% CI = 23, 61) of 996 participants from five studies met physical activity guidelines of at least 150 min per week of MVPA in absence of the bout criterion (Fig. 3, Table IV). There was moderate quality evidence that 19% (95% CI = 8, 33) of 1460 participants from nine studies met physical activity recommendations of at least 10,000 steps per day [Fig. 4(a), Table IV] and low quality evidence that 48% (95% CI = 31, 65) completed at least 7000 steps per day [Fig. 4(b), Table IV].

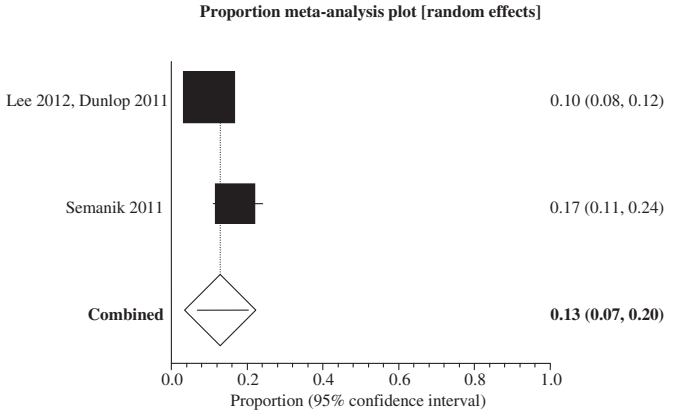

Fig. 2. Proportion meta-analysis of participants with knee osteoarthritis meeting physical activity guidelines of ≥150 min per week of MVPA in bouts of minimum 10 min. I^2 = 0%.

Proportion meta-analysis of participants with hip osteoarthritis meeting physical activity guidelines and recommendations

There was low quality evidence that 58% (95% CI = 18, 92) of 215 participants from five studies met physical activity guidelines of at least 150 min per week of MVPA in absence of the bout criterion (Fig. 5, Table IV). There was low quality evidence that 30% (95% CI = 13, 50) of 189 participants from four studies met physical activity recommendations of at least 10,000 steps per day [Fig. 6(a), Table IV] and low quality evidence that 60% (95% CI = 47, 73) completed at least 7000 steps per day [Fig. 6(b), Table IV].

Results from data excluded from meta-analyses

Several studies were not included in the meta-analyses. Data from eight studies could not be converted into moderate to vigorous intensity or number of daily steps. One of these eight studies, de Groot *et al.*[26,27], reported that participants with knee osteoarthritis spent 85 min walking per day and participants with hip osteoarthritis spent 92 min walking per day, which may have included light and moderate level activity. Data from four studies did not separate outcomes for knee and hip osteoarthritis and therefore could not be included. Data from one study did not report the standard deviation for the number of daily steps (Tables I–III).

Table IV
Summary of findings: proportion of participants meeting physical activity guidelines and recommended daily steps

Number of participants (studies)	Type of osteoarthritis	Physical activity guidelines	Proportion (95% CI)	I^2 (95% CI)	Epidemiological Appraisal Instrument	Quality of evidence (GRADE)
1228 (two studies)	Knee	≥150 min/day MVPA in ≥10 min BOUTS	13% (7, 20)	0%	91%	High
996 (five studies)	Knee	≥150 min/week MVPA	41% (23, 61)	97% (96, 98)	85%	Low*,†
1460 (nine studies)	Knee	≥10,000 steps/day	19% (8, 33)	96% (94, 97)	79%	Moderate†
		≥7000 steps/day	48% (31, 65)	96% (95, 97)		Low*,†
40 (one study)	Hip	≥150 min/week MVPA in ≥10 min BOUTS	54% (37, 69)	–	91%	–
215 (five studies)	Hip	≥150 min/week MVPA	58% (18, 92)	97% (96, 98)	84%	Low*,†
189 (four studies)	Hip	≥10,000 steps/day	30% (13, 50)	88% (67, 94)	86%	Low*,†
		≥7000 steps/day	60% (47, 73)	70% (0, 87)		Low*,†

GRADE = Grades of Research, Assessment, Development and Evaluation (GRADE Working Group);
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.
Reason for downgrade
* Imprecision (large CIs > 25%).
† Inconsistency (I^2 > 50 and no plausible explanation to explain inconsistency of results).

Sensitivity analyses

The I^2 remained greater than 50% in three of four sensitivity analyses when eliminating outlier data. The I^2 lowered to 2% in one of the four sensitivity analyses regarding the proportion of participants with hip osteoarthritis who met recommendations of at least 10,000 daily steps when data from the one outlying study[28] was removed; however, the proportion meeting recommendations did not change significantly.

Subgroup analyses

Subgroup analyses investigated the proportion of participants with severe knee and hip osteoarthritis (grade III/IV) meeting guidelines and recommended daily steps compared with the whole sample. For the proportion of participants meeting guidelines of 150 min per week of MVPA in absence of the bout criterion; 34% (95% CI = 16, 99) of participants with severe knee osteoarthritis met these guidelines compared with 41% (95% CI = 23, 61) for the whole population; 58% (95% CI = 1, 99) of participants with severe hip osteoarthritis met these guidelines compared to 58% (95% CI = 18, 92) for the whole sample. For the proportion meeting the popular recommendation of 10,000 daily steps; 28% (95% CI = 1, 71) of participants with severe knee osteoarthritis met these recommendations compared to 19% (95% CI = 8, 33) for the whole sample; 40% (95% CI = 27, 52) of participants with severe hip osteoarthritis met these recommendations compared to 30% (95% CI = 13, 50) for the whole sample.

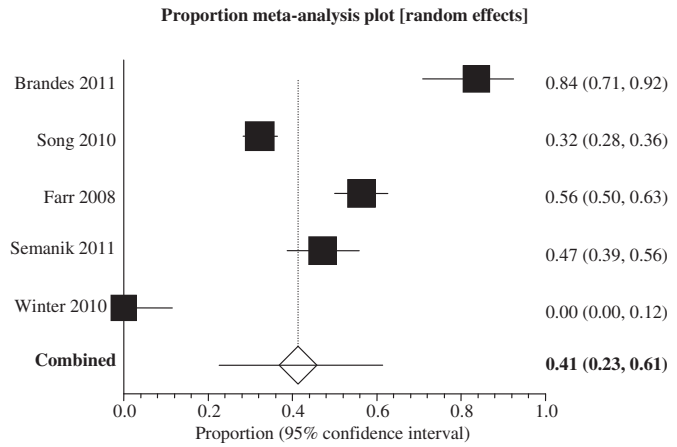

Fig. 3. Proportion meta-analysis of participants with knee osteoarthritis completing ≥150 min per week of MVPA in absence of the bout criterion. I^2 = 97% (95% CI = 96, 98).

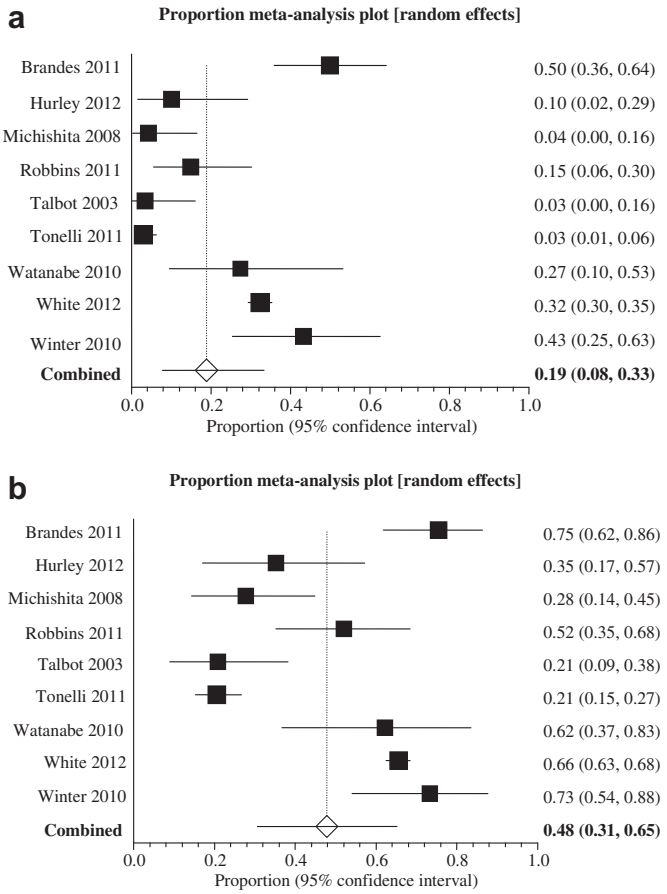

Fig. 4. (a) Proportion meta-analysis of participants with knee osteoarthritis completing ≥10,000 steps per day. I^2 = 96% (95% CI = 94, 97); (b) Proportion meta-analysis of participants with knee osteoarthritis completing ≥7000 steps per day. I^2 = 96% (95% CI = 95, 97).

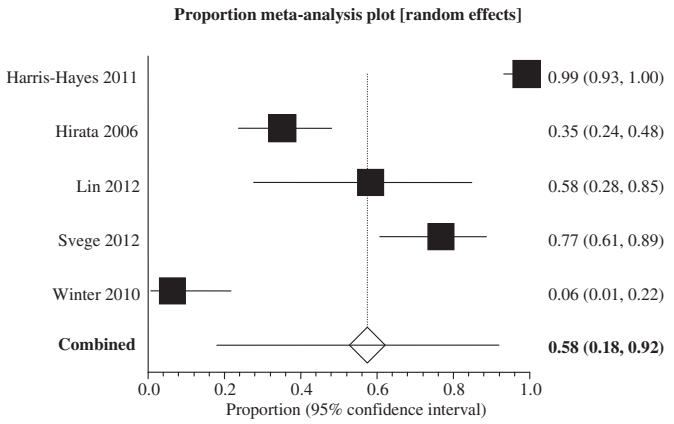

Fig. 5. Proportion meta-analysis of participants with hip osteoarthritis completing ≥150 min per week of MVPA in absence of the bout criterion. I^2 = 97% (95% CI = 96, 98).

Discussion

Summary of evidence

The results of this systematic review demonstrate evidence, ranging from low to high quality, that 13–60% of people with knee and hip osteoarthritis met current physical activity guidelines and recommendations of number of daily steps. The lowest proportion (13% for knee osteoarthritis) met guidelines of 150 min per week of MVPA when a minimum of 10 min bouts were required. The highest proportion (60% for hip osteoarthritis) accumulated 7000 daily steps and was similar to our finding for the proportion of people with hip osteoarthritis (58%) that met guidelines of at least 150 min per week of MVPA in absence of the bout criterion. This suggests that 7000 steps per day may be an accurate estimate of the current guidelines in absence of the bout criterion.

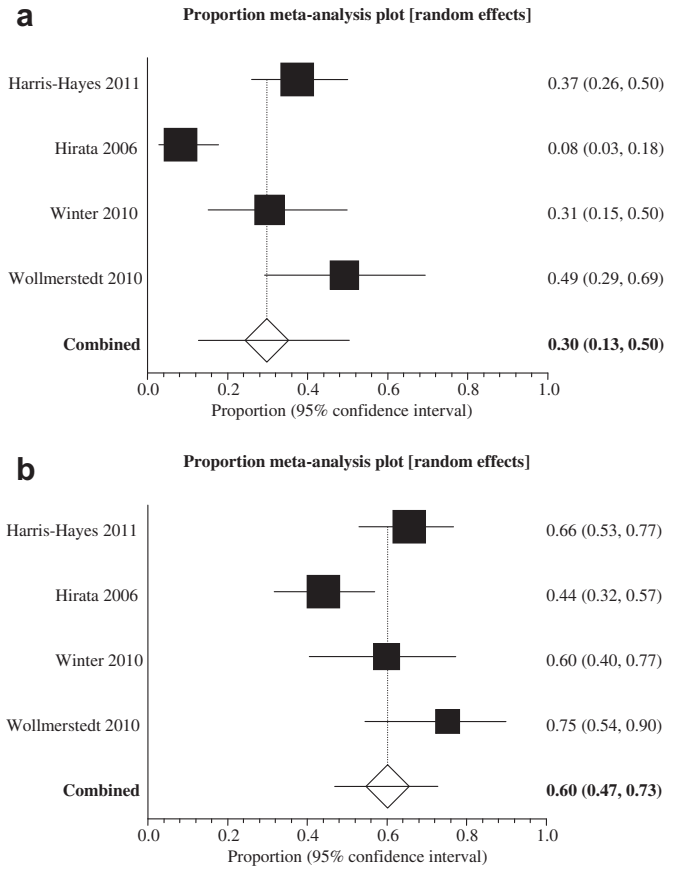

Fig. 6. (a) Proportion meta-analysis of participants with hip osteoarthritis completing ≥10,000 steps per day. I^2 = 96% (95% CI = 94, 97). (b) Proportion meta-analysis of participants with hip osteoarthritis completing ≥7000 steps per day. I^2 = 70% (95% CI = 0, 87).

While the majority of participants with knee and hip osteoarthritis do not meet current physical activity guidelines this may not be much less than age-matched peers without osteoarthritis. Data from large scale physical activity epidemiology studies of US adults using an accelerometer reported 16% of people met physical activity popular recommendations of at least 10,000 steps daily[11] and less than 5% met previous physical activity guidelines of at least 30 min daily of MVPA in 10 min bouts[29]. While these US adults may include adults with chronic diseases these findings appear similar to our findings for people with knee osteoarthritis. Data from our included studies that also measured physical activity levels for healthy controls showed that participants with hip and knee osteoarthritis performed 8835 daily steps compared to 11,859 daily steps for people without osteoarthritis[30–32]. Therefore, the participants with osteoarthritis were 75% as physically active compared to age matched peers without osteoarthritis when the same method of physical activity measured was applied.

Previous literature have found nondisease-related factors such as sex, age, body mass index, diet quality and psychosocial factors as well as disease-related factors such as pain, dysfunction and severity of osteoarthritis to be associated with lower levels of physical activity[1–5]. The results of our review showed considerable variability in physical activity between studies that is expected to be due to various disease and nondisease-related factors as well as methods applied by the studies to measure physical activity. For example, it would be reasonable to expect people with severe osteoarthritis to be less physically active than the people with mild or moderate osteoarthritis; however, none of the subgroup analyses showed clear differences and no consistent characteristics existed in the outlier studies.

Joint arthroplasty, a cost effective intervention that improves pain and function[33,34], is also expected to result in increased physical activity yet some studies have shown no increase in physical activity levels 6 months and 4 years after surgery[26,27,35–37] suggesting that there are other factors that contribute to low physical activity levels. Also the lower than expected difference in physical activity between people with osteoarthritis and aged-matched peers without osteoarthritis suggests that nondisease-related factors may be as important as disease-related factors in predicting physical activity levels for people with hip and knee osteoarthritis.

These findings that nondisease-related factors are important suggest that strategies to increase physical activity levels and health outcomes in patients with hip and knee osteoarthritis should target the nondisease-related factors as well as disease-related factors. Commonly applied and effective strategies for increasing physical activity include behaviour change techniques such as goal setting, self-monitoring strategies such as pedometers, engaging social support such as family members, and promoting these strategies for long term success such as regular reviewing of goals[38]. These strategies could be applied in conjunction with appropriate osteoarthritis interventions such as exercise programs, weight loss strategies, analgesic medications and joint arthroplasty.

The current physical activity guidelines of at least 150 min per week of MVPA in bouts of at least 10 min may be an appropriate

target for health care providers to recommend their patients with hip and knee osteoarthritis for improved health outcomes. A low to moderate proportion of people with osteoarthritis, including people with severe hip and knee osteoarthritis actually met the physical activity guidelines. Therefore, health care providers could adopt this target for their patients who have low levels of physical activity starting with levels that are easily manageable and gradually building up the recommenced frequency, duration and intensity. However, some caution may need to be applied as there is little evidence on the effects of increasing physical activity to these levels on the disease progression and health-related quality of life.

Limitations

There are several limitations for this review that may impact the results. Firstly, the selection criteria included studies on a minimum of 1 day of monitoring, which may be insufficient to represent typical physical activity per week. However 16 of the 18 studies used in the meta-analyses reported at least 7 days monitoring, one study reported between 5 and 10 days monitoring and one study reported 3 days monitoring which can be extrapolated to represent a typical week of activity. Secondly, for six of the seven meta-analyses in our review, there was low to moderate confidence in our findings due to inconsistency of physical activity levels for participants with hip and knee osteoarthritis and large CIs. This is despite 27 studies in this review and sensitivity and subgroup analyses which suggest there were no common factors to explain the variability of results. Many variables exist regarding the participants, the settings, the monitoring devices and methods that could explain the inconsistency of findings. For example Svege *et al.*[39] had a higher proportion of participants meeting guidelines; however, the participants received education about the importance of physical activity prior to enrolling in the study. Lastly, a number of assumptions are made to estimate physical activity from activity monitors as well as our method of calculating the proportion meeting guidelines which may impact the results. For example, activity monitors may underestimate physical activity by not capturing activities like swimming or biking, do not discriminate between walking and stair climbing, and may overestimate physical activity by increasing a person's awareness of monitoring[40,41]. However, activity monitors have shown high correlation with metabolic equivalents and total energy expenditure and the accuracy and test retest reliability have been established in many populations including osteoarthritis[41]. To determine the proportion meeting physical activity guidelines and recommended daily steps, where these data were not reported, required an assumption that the data were normally distributed. While physical activity data may be skewed, this would impact the estimates of physical activity by slightly overestimating the proportion meeting guidelines if the data were positively skewed.

Conclusion

A small to moderate proportion of people with knee and hip osteoarthritis met physical activity guidelines and recommended daily steps. Future research should establish the effects of increasing physical activity in this population to meet the current physical activity guidelines.

Authors' contributions

JAW designed the review, completed searches of databases and drafted the manuscript. KEW, PL and NFT contributed to review design, data analysis and contributed to the writing of the paper by revising it critically for important intellectual content. All authors read and approved the manuscript.

Conflict of interest

All authors declare that they do not have any potential conflict of interest.

Acknowledgements

None.

Appendix

Medline Search Strategy ($n = 1010$)

Population

S1	(MH "Knee") OR "Knee" OR (MH "Knee Joint")
S2	(MH "Hip") OR "Hip" OR (MH "Hip Joint")
S3	(MH "Lower Extremity") OR "Lower Limb"
S4	S1 OR S2 OR S3
S5	(MH "Osteoarthritis") OR "Osteoarthritis" OR (MH "Osteoarthritis, hip") OR (MH "Osteoarthritis, knee") OR (MH "Arthritis") OR "Arthritis"
S6	Osteoarthr* OR Degenerat*
S7	S5 OR S6
S8	S4 AND S7

Outcome

S9	(MH "Physical Endurance") OR (MH "Physical Exertion") OR (MH "Physical Fitness") OR (MH "Motor Activity") OR (MH "Locomotion")
S10	"Physical* Activ*" OR "Physical* Fit*" OR "Aerobic* Fit* OR "Cardiovascular Endurance" OR "Energy Expend*" OR "Bodily Movement" OR "Activity Monitor" OR "Cadence" OR "Accelerometer*"
S11	S9 OR S10
S12	**S8 AND S11**

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